U.S. Department
of Transportation

**INTELLIGENT
TRANSPORTATION
SYSTEMS (ITS)**

Assessment of

ITS Benefits

Early Results

101046

NOTICE

Intelligent
Transportation
Systems (ITS)

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ITS Benefits
Early Results

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FOREWORD

This report was prepared by Donald L. Roberts and Dwight E. Shank of Mitre under the sponsorship of the Federal Highway Administration. It provides an early assessment of some of the ongoing uses and benefits of Intelligent Transportation Systems (ITS). These benefits derive from programs that are sponsored by the private sector, public sector, and public/private partnerships. It is *not* a complete and comprehensive analysis of benefits of all of the ITS activities, but it does provide a significant look at emerging results.

In order to provide a context to present these benefits, this report is organized under five of the National ITS Program goals. They are further grouped under the supporting objectives of each goal. It is anticipated that this report will be used primarily as a reference source, thus the specific references are provided at the bottom of each page and also as a group at the end of the document. Because of the limited data currently available from the field, it is risky at this time to draw absolute conclusions about the degree of attainment of any goal. However, results from completed and ongoing operational tests will be available soon for a number of projects.

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SECTION 1

1.1 BACKGROUND

Without doubt, the Federal government is a major player in the ITS arena. Federal funding and leadership have been essential in several completed and evaluated tests including SmarTraveler in Boston, Pathfinder in Southern California, TravTek in Orlando, and Help/ Crescent project stretching from Texas into British Columbia. These projects represent the leading edge of the results from the Federal program that will confirm, adjust, and support various benefits anticipated from ITS. Additionally, state and local governments continue to independently implement and innovate transportation systems using ITS technologies. Private concerns are moving even more quickly to develop systems that provide either competitive advantage or significant market potential. The following text gives an overview of benefits from many types of systems, with an emphasis on systems that have realized benefits in real-world operation. Many of the benefits are measured either system-wide or for a subset of the system, while others represent projected benefits as a result of simulation and analysis.

It should be noted that many of the projects that currently have definitive evaluation results began well before the ITS era and are now evolving to incorporate the rapidly emerging ITS technologies. Examples of such early, evolutionary deployments include transit management systems, freeway management systems, ramp metering systems, incident management programs, and traffic signal systems. These types of systems are being considered as key elements of the core infrastructure for the 75 major metropolitan areas by the United States Department of Transportation (DOT) ITS Joint Program Office.

1.2 ORGANIZATION

In order to provide a context to present these benefits, this report is organized under five of the National ITS Program goals.’ They are further grouped under the supporting objectives of each goa1[2]. In addition key words such as program name, ITS product, location of activity, etc. are in bold to facilitate information access.

1 Euler, G., and Robertson, D., Ed., National ITS Program Plan, First Edition, Available through ITS America, Washington, DC, March 1995

2 Bolczak, R., Meta-Evaluation Applied to Results of ITS Initiatives, The MITRE Corporation, WN-95WOOOOO48, Washington, DC, April 1995

In compiling these data, some results could have been counted under more than one goal area and in some cases the discussion of the results from a single project may apply to more than the specific goal where the discussion appears. At this point in time the approach has been to keep these discussions intact and to locate the information arbitrarily under one goal with references to other relevant goals.

It is anticipated that this report will be used primarily as a reference source, thus the specific references are provided at the bottom of each page, and also as a group at the end of the document. No attempt has been made to provide complete and comprehensive results for each program discussed. The approach is to provide significant highlights that relate to a specific ITS goal and references to sources of more comprehensive data.

NATIONAL ITS GOALS

SECTION 2

This section will discuss the benefits from a number of ongoing programs and relate them to the goals of the ITS program. These goals as stated in the National ITS Program plan are:

- Improve the safety of the Nation's surface transportation system
- Increase the operational efficiency of the surface transportation system
- Reduce energy and environmental costs associated with traffic congestion
- Enhance present and future productivity
- Enhance the personal mobility and the convenience and comfort of the surface transportation system
- Create an environment in which the development and deployment of ITS can flourish

Because of the nature of this study, specific benefits from a project related to an ITS goal, the last goal is not addressed since all ITS products will contribute to its achievement.

2.1 IMPROVE THE SAFETY OF THE NATION'S SURFACE TRANSPORTATION SYSTEM

There are two primary objectives of this ITS goal: reduce the frequency of accidents and reduce the severity of accidents. The following are a few examples of programs and the resultant benefits that address the first objective, reduction in the frequency of accidents. These safety benefits have been realized and quantified from some of the evolutionary deployments as well as from some new ITS devices.

Another important aspect of safety is the personal security of the traveling public. These safety benefits are identified in Section 2.5.

2.1.1 Reduce Accidents — Advanced Traveler Information Systems (ATIS)/Advanced Traffic Management Systems (ATMS)

The safety potential for an advanced traffic information system that warns commercial vehicles and other heavy vehicles of a potentially dangerous highway situation is being tested. **The Dynamic Truck Speed Warning System for Long Downgrades** has been installed in the Eisenhower tunnel on I-70 west of **Denver.** This system warns drivers of safe truck speed at start of the downgrade for normal operations based on truck weight. The Colorado Motor Carrier Association is excited about the potential for improved safety represented by this device. Prior to the project, the state studied accident characteristics and discovered that 88%[3] of the runaway trucks were out-of-state and

[3] Fulton, G., Colorado DOT, Telephone Interview, January 1995

that they entered runaway truck ramps at speeds of up to 110 mph. Data from operation of the system are expected to become available during 1995.

The use of **video surveillance** for traffic law enforcement is a more controversial area of potential benefits derived from ITS. A few pilot studies are in place in the United States, such as a signal compliance device in **New York City.** European countries have been more willing to use automated enforcement devices. Installation of speed enforcement cameras in **London** have reduced speed by approximately l0%, accidents by 20% to as much as 80% and serious injuries and fatalities by about 50%. An additional benefit is that 98% of all parties intended for prosecution are not contesting the citations[4].

2.1.2 Reduce Accidents — Advanced Vehicle Control and Safety Systems

Blind spot detectors are becoming available as commercial products. One product that has been in use since 1993 is **the Forewarn** system applied to school buses. In a recent year, 33 school children were killed by buses, 67% by the bus they just exited. Although quantitative benefits are not yet available, pilot programs in states considering deployment have gone exceptionally well, with many drivers having stories of situations in which the system told them of the presence of children who were in harms way[5].

Automated Highway System (AHS) related products can have safety benefits prior to full implementation of AHS segments. Based on data from **Minnesota[6],** 60% of rural freeway accidents are susceptible to reduction using lane keeping and collision avoidance technologies. These types of collisions include run-off-the-road, accounting for 34% of accidents, and animal hits. A reduction of just 40% in these accidents could account for an annual reduction of 19,000 accidents including 190 fatal accidents nationally accounting for an estimated cost savings of $225 million. Applying the same type of analysis to urban areas shows the most common types of accidents to be rear end (50%), run-off-the-road (22%), and side swipe (13%). These also are susceptible to correction with less than full implementation of AHS. Assuming a reduction of 35% of these accidents, 52,000 fewer collisions could be expected to occur on a national basis, including 100 fatal accidents. (The results are summarized in Table 2- 1.)

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4 Harris, J. and Sands, M., Speed Camera Advances, Traffic Technology International, Spring 1995

5 Himelick, J., Delco Electronics, Telephone Interview, March 1995

6 AHS Precursor Analyses, Activity Area A, Urban and Rural AHS Analysis, Battelle, BRW, and Transportation Research Center, 1994

Table 2-1

Rural	
Accidents Susceptible to Reduction	60%
• Run-off-road	34%
• Other	26%
Accidents Prevented	
(Assume 40% success rate with AHS products)	19,000
.40 (total rural accidents x .60)	
Fatal Accidents Prevented	190
Cost Savings from Accidents Prevented	$225M
Urban	
Accidents Susceptible to Reduction	85%
• Run-off-road	22%
• Rear end	50%
• Side swipe	13%
Accidents Prevented	
(assume 35% success rate with products)	52,000
.35 (total urban accidents x .85)	
Fatal Accidents Prevented	100
Cost Savings from Accidents Prevented	$475M

Applicability of AHS Products to Rura/Urban Accident Reduction

2.1.3 Reduce Accidents — Commercial Vehicle Operations

ITS User Services are expected to improve the safety record of motor carriers. Electronic clearances, improved inspection procedures, and vehicle performance monitoring will help to eliminate major causes of accidents through better use of communications and information technology. An early **information network** in Oregon enabled an increase of 90% in weighings and 428% in safety inspections between 1980 and 1989 while staff increased by only 23%[7]. Further evidence of future success is indicated by ongoing motor carrier safety programs including the **Motor Carrier Safety Assistance Program** (MCSAP) and federal safety audits. The benefit/cost ratio of these programs has been estimated as 2.5 while yielding a reduction of 2,500 – 3,500 accidents annually.[8] Use of improved brake inspection technology will

7 Krukar, M. and Evert, K., Integrated Tactical Enforcement Network (Automated Enforcement Facilities in Oregon), Presented at the National Traffic Data Acquisition Technologies Conference, Austin, TX, 17 -20 August 1990

8 Moses, L. and Savage, I., A Cost-Benefit Analysis of the Federal Motor Carrier Safety Programs, 3rd Version, Department of Economics and the Transportation Center, Northwestern University, Evanston, IL, 1993

reduce inspection time by 10-15 minutes. Use of pen-based computers will reduce the duplicate input of inspection report data, resulting in potential savings of 125 staff years annually.[9]

2.2 INCREASE OPERATIONAL EFFICIENCY AND CAPACITY OF THE SURFACE TRANSPORTATION SYSTEM

There are three primary objectives of this ITS goal: increase the capacity of the transportation system, reduce congestion due to incidents and improve transportation customer service. Capacity increases are closely related to the productivity objective of reducing travel time since, many capacity improvements relieve bottlenecks that lead to travel delays. Similarly, delay reduction programs can result in an increase in capacity. (Reference Section 2.4.4.)

2.2.1 Increase Capacity — Ramp Metering

The first ramp meter was installed on the Eisenhower Expressway in Chicago in 1963[10]. Other early adopters of freeway ramp meters include Minneapolis and Los Angeles. By 1989, Federal Highway Administration (FHWA) had enough data to put together a summary of ramp metering practice with quantitative results. As places such as Minneapolis upgrade their ramp meter systems into true Freeway Management Systems, results continue to improve along with coverage, capability, and coordination. Glen Carlson of **Minnesota DOT** provided the following statistics from the Traffic Management Center (TMC)[11]: Capacity is 2200 vplph compared with 1800 prior to the use of the ramp meters. (The 1994 revision of **the Highway Capacity Manual** suggests 2200 to 2300 vplph as a standard capacity for basic freeway segments.) Average speeds have risen from 34 MPH to 46 MPH. Accident rates on I-35W before management were 421 per year and are now 308 per year (27% reduction). Annual accident experience on I-35W after management are 2.11 collisions/MVM (per million vehicle miles) compared to 3.40 before management was instituted. (Reference Section 2.1.1.)

A longitudinal study of the ramp metering/freeway management system in the **Seattle, Washington** area over a six year period[12] shows a growth in traffic of 10% to 100% along various segments of I-5 while speeds have remained steady or increased up to 20% and accident rates have fallen consistently to a current level of 62% compared to

9 mcKelvey Doug, FHWA OMC, Personal Files

10 Doctor, M., and Robinson J., Ramp Metering Status in North America, Final Report, September 1989, Office of Traffic Operations, Federal Highway Administration

11 Freeway Operations Meeting Minutes, January 1994

12 Henry, K., and Meyhan, O., 6 Year FLOW Evaluation, Washington State DOT, District 1, January 1989

the base period. (Reference Section 2.1.2.) This has occurred while average metering delays at each ramp have remained at or below 3 minutes.

The Information for Motorists **(INFORM)** program is an integrated corridor on **Long Island, New York** providing information via variable message signs (VMSs) and control using ramp meters on parallel expressways and some coordination on arterials. The program stretches back to concept studies in the early 1970s and a major feasibility study performed from 1975 to 1977. The implementation progressed in phases starting with VMSs, followed by ramp meters in 1986 and 1987 and completed implementation by early 1990.

Estimates of delay savings due to motorist information[13] reach as high as 1900 vehicle-hours for a peak period incident and 300,000 vehicle-hours in incident related delay annually. Drivers will divert from 5--10% of the time when passive (no recommended action) messages are displayed and twice that when messages include diversion messages. Convenient alternate routes also have a major impact on diversion. Drivers will divert starting several ramps prior to the incident, with typically 3-4% of drivers using an individual exit ramp. This represents an increase in ramp usage of 40-70%. Accident frequency decreased slightly during the study, but data were insufficient to claim a significant trend.

In studies comparing 1987 to 1990 flow in the area of INFORM measuring benefits from ramp metering in combination with motorist information, freeway speeds increased 13% despite an increase of 5% in VMT for the PM peak. Maximum throughput showed mixed results, showing 7% increases in some areas and no change in others. The number of detectors showing speed less than 30 MPH decreased 50% for the AM peak. Average queue lengths at ramp meters ranged from 1.2 to 3.4 vehicles, representing 0.1% of vehicle hours traveled.

Public perception of information accuracy was of great interest to the INFORM project and the results in this area were generally favorable. 29% of survey respondents rated the information as very useful and 75% as moderately useful or better, 63% rated the information as usually or always accurate. 45% said that they sometimes changed their routes based on the information. Public views on ramp meters were split, 40% viewed ramp meters as good and another 40% did not think that they were a good idea.

13 Smith, S. and Perez, C., Evaluation of INFORM - Lessons Learned and Application to Other Systems, Conference Paper Presented at 71st TRB, January 1992

2.2.2 Increase Capacity — Route Guidance

Traffic and traveler information systems are being widely tested, and deployments are underway. The tests are producing data that anticipate system benefit when wider deployment appears. **The Pathfinder** project implemented an in-vehicle navigation and motorist information system including access to real-time traffic information. The project was implemented in **Los Angeles** in the area of the **Smart Corridor.** The expectation here is that increasing driver navigational effectiveness will increase the capacity of the system by minimizing "wasted miles" while searching for the trip destination point. It should also reduce the overall travel time of the tip. The evaluation[14] stated that Pathfinder delivered meaningful user benefits including fewer travelers failing to follow their desired route and may offer benefits to the highway network as a result of drivers' increased willingness to divert. Drivers perceived that their trip was less stressful using Pathfinder and that their travel times were lower. Drivers also were 40% more likely to divert using Pathfinder. In paired tests comparing use of Pathfinder with dynamic route guidance, map display only, and without the device operating, few statistically significant differences were noted in travel time, travel speed, or travel distance. Due to the small number of equipped vehicles, no impacts on the traffic network were expected, and no data were collected on network impact.

Encouraging indications of potential **Advanced Traveler Information Systems** (ATIS) benefits were obtained in initial simulations, using the urbansville scenario[15], performed as part of the **National ITS Architecture** study. For networks with congestion causing increases of up to a factor of 3 from free flow travel time, but before saturation, equipped vehicles (with navigational aids allowing fixed and dynamic route guidance) experience a 8%-16% reduction in travel time for all types of trips. Unequipped vehicles, also benefited, although to a lesser extent with a 2% reduction. If the network is saturated or there is little congestion affecting travel time, the advantage of equipped vehicles dissipates. These simulations were performed using an ATIS market penetration level of 5%.

Field studies[16] performed during the **TravTek** project in **Orlando, Florida** showed that vehicles with an active TravTek device experienced a decrease in travel time of 19% if the route is followed properly, a 20% decrease in travel time if turns are missed (i.e., when turns are missed by both TravTek and the unequipped control vehicle,

14 Pathfinder Evaluation Report, Prepared for California Department of Transportation, JHK & Associates, Pasadena, CA, February 1993

15 Wunderlich, K., The MITRE Corporation, Unpublished Data

16 Van Aerde, M., et al., Simulation-Based Estimates of Benefits to TravTek Drivers and Other Network Users, to be Published in IVHS Journal Issue

TravTek provides time savings in regaining the desired route), and a decrease in probability of missing a given turn from 5.4% to 3.6%. Using these data as input along with the Orlando travel network, a simulation using the **INTEGRATION** simulation tool showed improvements on a regional basis in areas including travel time, trip distance, pollutant emissions, and accident risk for most levels of market penetration. More detailed results will be available as publication of TravTek documents progress.

2.2.3 Reduce Congestion — Incident Management

Incident management programs are following an evolutionary route to full deployment. Many of the existing incident management systems such as the Highway Helper Program in Minneapolis, the Incident Management component of the CHART Program in Maryland, and the Emergency Traffic Patrol in Illinois began as "eyes and ears" of motorists, incorporating technology such as cellular call-in, loop detectors, video surveillance, and video detectors as technology and budget constraints allowed. Incident management programs yield significant results toward reducing the 50-60% of traffic congestion attributable to incidents.

The **Minnesota Highway Helper** Program[17] reduces the duration of a stall (the most frequent type of incident, representing 84% of service calls) by 8 minutes. Using representative numbers, annual benefit through reduced delay totals $1.4 million for a program that costs $.6 million to operate. The reduction in secondary collisions due to the incident management program is difficult to estimate due to the coordinated freeway management program in the area discussed earlier.

As stated above, **the Maryland CHART** program started as an "eyes and ears" program and now is in the process of expanding to more automated surveillance with lane sensors and video cameras. This program is expected to return about a 10: 1 [18] benefit/cost according to draft analyses.

An analysis of the accident statistics on several **California** arterials and expressways shows that secondary accidents, as a result of an incident, represent an increase in accident risks of over 600%[19] (i.e.,

17 Highway Helper Summary Report Twin Cities Metro Area, Report # TMC 07450-0394, July 1994, Minnesota Department of Transportation

18 Kuciemba, S., The Maryland State Highway Administration, Telephone Interview, March 1995

19 Tedesco, S., et al., Development of a Model to Assess the Safety Impacts of Implementing IVHS User Services, p. 343, Proceedings of the 1994 IVHS America Annual Meeting

secondary accidents are 6 times more likely). Therefore, any ITS system which reduces the duration of incident, should also reduce the number of secondary accidents. (Reference Section 2.1.2.)

2.2.4 Improve Transportation Customer Satisfaction — Transit Services

For nearly a decade, transit properties and emergency vehicle operators have been installing and using vehicle location systems based on signpost, triangulation, Long RAnge Navigation (LORAN), and Global Positioning System (GPS) technologies[20]. At least 21 transit operators currently have up to 12,000 vehicles equipped and in operation, with others planning to implement in 1995. Coupled with computer-aided dispatching (CAD) systems, the vehicle location technologies are leading to impressive gains in service reliability, safety, and cost-effectiveness. The **Mass Transit Administration in Baltimore** reported a 23% improvement in on-time performance by buses equipped with Automatic Vehicle Location (AVL) devices. The **Kansas City Area Transportation Authority** reported improved schedule adherence of 12% in the first year after installation of an AVL system. The **Milwaukie County Transit System** has realized a 28% reduction in off-schedule buses with the introduction of an AVL system for their fleet of 543 buses[21]

2.3 REDUCE ENERGY AND ENVIRONMENTAL COSTS ASSOCIATED WITH TRAFFIC CONGESTION

There are three primary objectives of this ITS goal: reduce harmful emissions per unit of travel, reduce energy consumption per unit of travel, and reduce new transportation right-of-way requirements.

Environmental benefits from a given project can really only be estimated by analysis and simulation with the exception of highly localized measures such as air quality surrounding a particularly snarled intersection or other point of interest. An example of local air quality benefit is the reduction of emissions using **signal system optimization** in the “Five Points” area of **Las Vegas**[22]**.** The problems related to regional measurement include small impact of individual measures and large numbers of exogenous variables including weather, contributions from non-mobile sources or other regions, and the time evolving nature of ozone pollution. With two potential exceptions, the environmental benefits of ITS services will be modest at best. The two areas which may yield significant benefits are congestion/road pricing

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20 Jones, W., ITS America Research Survey, 1995

21 Giugno, M., Milwaukie County Transit System, July 1995 Status Report

22 Reduction in Localized Carbon Monoxide Emissions, Draft, Submitted to the Clark County Health District by Barton-Aschman Associates, Inc., November 1994

and the use of remote sensing technology to detect gross polluters. The following results only address the objective of reducing harmful emissions per unit of travel.

Several-studies including one from **Illinois Department of Transportation (DOT)**[23] and another from the **National Research Council**[24] report that 60% of the mobile source pollution arise from "gross polluters" comprising only 10% of the vehicles. The **Arizona Department of Environmental Protection** has implemented a **program** in the **Phoenix** area, which is a non attainment area for ozone, to use a remote sensing device to identify gross polluters[25]. The first identification will yield a warning from the state, the second will yield a notice to report to an inspection station. The emission levels for notification from the remote device are set at roughly 21/2 times the legal limit so that a vehicle referred to a test station will in fact fail the test. Failure to comply with the inspection notice will result in suspension of vehicle registration. The impact of this program on emissions from gross polluters is yet to be determined. Two operational tests are under development that test concepts to identify these vehicles and bring down their pollution levels. The **voluntary emissions compliance test** near **Denver** is in the calibration stage. The remote emissions monitoring technology has been used previously, but the overall impact of such a device is not yet known.

Environmental benefits are expected to be modest in size, unless congestion pricing becomes reality. Typical travel demand management benefits are on the order of 2-4%[26] reductions in overall vehicle miles traveled (VMT), as well as hydrocarbon (HC) and carbon monoxide (CO) mobile source emissions. Reducing oxides of nitrogen (NOx) by even this amount is more uncommon in the benefits analysis. Similar magnitude results accrue from flow improvements via TMCs on freeways. Benefits of this magnitude are unfortunately similar in magnitude to a single year's growth in VMT. Signal coordination and optimization claim emission benefits in the range of l0%, in addition to travel time improvements. (Reference Section 2.4.) This size of benefit contrasts with vehicle improvements leading to a reduction in vehicle sources of 39% for HC and 40% for CO while VMT increased 41% in

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23 Cleaning the Air, Choosing the Future: Reducing Highway Vehicle Emissions in the Chicago Non-Attainment Area, Environmental Planning and Economics, Inc., Submitted to the Illinois Department of Environment and Natural Resources, Springfield, Illinois, 1992

24 Rethinking the Ozone Problem in Urban and Regional Air Pollution, National Research Council, National Academy Press, 1991

25 Cox, F., The Arizona Department of Environment, Telephone Interview, April 1995

26 Clean Air Through Transportation: Challenges in Meeting National Air Quality Standards, Joint Report of USDOT and USEPA Pursuant to Section 108(f)(3) of the Clean Air Act, August 1993

the decade from 1982 to 1991. In a report produced for the **Illinois DOT",** planners basically pass traffic flow improvements off as a short term benefit rather than a longer term building block for emissions reductions, saying that flow improvements simply allow more dispersed land use patterns. Small benefits are also expected from electronic toll collection (discussed below) and commercial vehicle operations (CVO) border crossing/weigh station bypass.

Surveys performed in the Seattle, Washington area and the **Boston, Massachusetts** area indicate that when provided with better traveler information, there is a nearly even split between travelers who change route of travel and travelers who change time of travel, with an additional 5%-10% [28]changing travel mode based on traveler information. Assuming that 30% of 96,000 daily callers change travel plans according to this breakdown, the impact of **SmarTraveler in Boston** on emissions has been estimated using the MOBILE5a model. On a daily basis, this adjustment of travel behavior nets an estimated reduction of 498 kg of volatile organic compounds, 25 kg of NOx, and 5032 kg of CO representing reductions of 25%, 1.5%, and 33% respectively of these pollutants from travelers changing travel plans. While this represents significant reductions for participating travelers, only 28,800 daily trips are expected to be affected in a metropolitan area with 2.9 million registered drivers.

The **Pike Pass** electronic toll collection program on the Oklahoma Turnpike started operation on 1 January 1991. To June 1994,250,OOO passes had been issued, of which over 90% (226,000) were still active, accounting for 35% of the turnpike associations revenue. Using a protocol prepared from the Northeast States for **Coordinated Air Use Management** (NESCAUM), the Clean Air Action Corp.[29] estimated toll booth emissions based on dynamometer tests and toll road observation at **Muskogee Turnpike in Oklahoma, Asbury Plaza on the Garden State Parkway in New Jersey** and **Western Plaza on the Massachusetts Turnpike.** This report takes the experiences gained with the Pike Pass project and applies them to the other two freeways. The significant reduction in tons of pollutants for the 260 day commuter case should be noted. Percent change is of course dependent upon frequency of toll plazas. Per mile of impacted operation, the following average emissions reductions are calculated in Table 2-2.

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27 Cleaning the Air, Choosing the Future

28 Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, Tech Environmental, Inc., July 1993

29 Proposed General Protocol for Determination of Emission Reduction Credits Created by Implementing an Electronic Pike Pass System on a Tollway, Clean Air Action Corp. Study for the Northeast States for Coordinated Air Use Management, December, 1993

Table 2-2

Speed Profile (mph)	65-0-65 Toll Gate	65-30-65 Limited Pass	65 Even Full Pass
HC	1.2 g/mi	1.0 g/mi	.2 g/mi
NOx	1.1 g/mi	.9 g/mi	.6 g/mi
CO	30.6 g/mi	20.0 g/mi	8.5 g/mi
Assuming a transaction uses the average measured distance of .55 miles, each cycle produces			
HC	.66 g	.55 g	.11 g
NOx	.61	.50 g	.33 g
CO	16.8 g	11.0 g	4.68 g
The equivalent number of highway miles for a stop cycle translates to			
HC	3.3 mi	2.75 mi	.55 mi
NOx	1.01 mi	.83 mi	.55 mi
CO	1.98 mi	1.29 mi	.55 mi
Percent increase compared to a freeway mile			
HC	500%	400%	0%
NOx	83%	50%	0%
CO	260%	135%	0%
Based on 260 commuter days/year in summer conditions with 100% implementation, reduction in tons per year — New Jersey			
HC	0	161	596
NOx	0	126	290
CO	0	6414	12681
Reduction in tons per year — Massachusetts			
HC	0	134	206
NOx	0	57	84
CO	0	2403	3441
Assuming 100% removal of toll delay, reduction from congestion relief alone — New Jersey, in tons per year			
HC	0	52	52
NOx	0	17	17
CO	0	653	653
Reduction from congestion relief alone — Massachusetts, in tons per year			
HC	0	116	116
NOx	0	39	39
CO	0	1447	1447

Calculation of Emissions Reduction Through Use of Electronic Toll Collection

2.4 ENHANCE PRESENT AND FUTURE PRODUCTIVITY

There are three primary objectives of this ITS goal: reduce costs of fleet operators, operating agencies and individuals; reduce travel time; and improve transportation system management and planning. The following are a few examples of programs and the resultant benefits that address reduction of costs.

2.4.1 Cost Savings for Operating Agencies — Electronic Toll Collection

Electronic Information Exchange for fare payment and clearance of commercial vehicles represent areas of high benefit potential. The **Detroit, MI to Windsor, Ontario** area experiences about 22 million border crossings annually, with roughly 75% of the crossings being made by daily crossers[30] The **NAFTA** and development of local attractions such as the Windsor Casino are likely to cause significant increase in demand. Implementation of **Automated Vehicle Identification** (AVI) for use with Electronic Toll Collection and Customs and Immigration automation has the potential to benefit both the toll authorities and the Customs offices with payback on electronic equipment investment in less than five years for toll authorities and less than ten years for customs. If potential economic development is included, government payback is in one year. For auto users, delay costs would repay investment in about 2 years. Commercial vehicles would get a benefit/cost ratio of over 4 in a single year, again primarily due to delay reductions. Additional benefits would accrue in ability to defer infrastructure investment, with benefit/cost ratio estimated at 30: 1[31].

The **Oklahoma Turnpike** has been operating electronic toll collection in the **Pike Pass** program for over four years with excellent results. Statistics from the Turnpike indicate a 9 1% savings in annual cost per lane[32]:

Annual cost to operate automated lane	$15,800
Annual cost to operate an attended lane	$176,000.

The clear benefit of ETC Systems to both operating agency and patron is evidented by the rapid growth in ETC deployments. ETC projects in **Oklahoma** and New **York** report healthy growth in patronage and overwhelmingly positive user feedback. ETC is currently deployed by eleven agencies from **New York** to **Florida** to **California**[33]**. The New York State Thruway** reports that requests for

30 Study of Institutional Impacts of New Technology Applications: St. Clair and Detroit Rivers Highway Border Crossings, Marshall Macklin Monaghan Limited with KPMG, JHK, & Constance Consultants, May 1994

31 Zavergiu, R., Unpublished Analysis Performed for Transport Canada

32 Oklahoma Turnpike Authority Pike Pass Facts

33 Gallagher, M., IBBTA, Telephone Interview

the **AMTECH EZPass** have reached 90,000 in the first 15 months of operation in a limited deployment of four toll barriers and a bridge[34]. **The Transportation Corridor Agency** in **Southern California** has between 6,000 and 7,000 users for a four-mile segment limited access toll road[35]. Additional ETC systems are being installed including the **Interagency Group in the New York metropolitan area,** the **Kansas turnpike Authority, the California Department of Transportation,** the **California Private Transportation Company,** and the **Maine Turnpike.**

2.4.2 Cost Savings for Fleet Operators

The Commercial Vehicle Operations (CVO) area continues to be viewed as a potential early winner for the use of ITS products. Some commercial technologies have been deployed by private firms such as centralized dispatch. Several major carriers, including **J. B. Hunt,** have deployed 2-way data communications, on-board computers, and automated vehicle location systems in their fleets. [36] In conjunction with IBM, Hunt developed an On-Board Computer system consisting of a 386-processor, a touch-screen display, and flash memory and including limited communication capability. Hunt finds the computers beneficial in terms of both driver satisfaction and vehicle utilization. These areas are critical in the truckload carrier business. Driver turnover can run over 100% annually with drivers (usually men) away from home for periods of several days. The ability for family members to contact drivers on the road via a limited message set has contributed to Hunt reducing driver turnover to the 80% range. Equally as important as the reduction in turnover, the computers along with a RISC-based computerized dispatching system have allowed Hunt to increase vehicle utilization by 20-25 miles per truck per day with a corresponding increase in driver productivity. These computer products are now being marketed. In an industry where operating ratio (expense/revenue) is frequently in the low to mid nineties and that has labor as a quarter of total costs, such improvements of 4-5% represent a significant competitive advantage.

Productivity improvements reported by motor carriers (in a 1992 study) using advanced vehicle monitoring and communications (AVMC) technology provide a further indication of the magnitude of

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34 O'Neill, G., The NY State Thruway Authority, Telephone Interview

35 Tadej, P., Lockheed IMS, Telephone Interview, March 1995

36 Pianalto, H., and Brooks, G., J. B. Hunt Trucking of Lowell, Arkansas, Telephone Interview

these benefits[37]. For intercity irregular-route trucking, **Telesat Canada** estimates use of its system will increase loaded mileage 9% to 16% and reduce operating costs $.12 to $.20 per truck mile. **Schneider** of **Green Bay, WI** reports a 20% increase in loaded miles and the elimination of check calls saves approximately two hours per day resulting in a driver salary increase of $50 per week, but that the primary benefit is improved customer service. **Trans-Western Ltd.** of **Lerner,** CO credits their system for improved driver relations, noting that drivers are able to drive 50 to 100 additional miles per day and driver turn-over has decreased from 100% to **30%. Frederick Transport** of **Dundas, Ontario,** estimates an increase of 20% in loaded miles, a reduction of $30 from $150 per month in telephone charges, 0.7% greater load factor and 9% increase in total miles. **North American Van Lines** of **Fort Wayne, IN** reports 16.9% additional shipments, 5.7% fewer deadhead miles, 3.8% fewer cancellations and 24.5% expedited pickups and deliveries. **Best Line** of **Minneapolis, MN** estimates a $10,000 a month savings since 300 drivers previously lost about 15 minutes each day waiting to talk with dispatchers. **Mets** of **Indianapolis, IN** performed tests that showed vehicle utilization increased by 13%. In addition, **United Van Lines** of **Fenton, MO** claims that the ability to track and recover stolen vehicles is expected to reduce theft insurance premiums.

Additional results are provided in an ATA Foundation 1992 survey[38] of 69 trucking companies operating in an urban area. More than half of the 69 companies surveyed use CAD systems. Productively gains resulted from an increase in the number of pickups and deliveries per truck per day, ranging from 5% to more than 25%, with most gains being clustered in the l0-20% range. The use of two-way text communication systems yielded driver time savings of 30 minutes per day because of the reduced time spent locating and using telephones.

Further anecdotal evidence of benefits to carriers is accumulating[39]. A mid-west leasing company will recoup a $5,400 per vehicle investment in vehicle tracking, communications, and electronics in one year. An automated routing system allowed a restaurant service company to reduce its transportation costs from 4.5% to 3.5% of total expenses. Vehicle tracking and mapping software allowed a national

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37 Hallowell, S., and Morlok, E., Estimating Cost Savings From Advanced Vehicle Monitoring and Telecommunicating Systems in Intercity Irregular Route Trucking, Department of Systems, University of Pennsylvania, Philadelphia, PA, January 1992

38 A Survey of the Use of Six Computing and Communications Technologies in Urban Trucking Operations, ATA Foundation, Inc., Alexandria, VA, 1992

39 McKelvey, Doug, FHWA OMC, Personal Notes

carrier to double dispatch productivity and reduce telephone usage by 60%. A recent ATA study found benefit/cost ratios greater than one for electronic clearance and one-stop shopping.[40]

Motor carriers are currently involved with development of additional fleet equipage related to electronic tags, enhanced communications, and potential CVO architecture standards. A study of **real-time diversion** of truckload carriers predicted an additional productivity improvement of 6%.[41] Currently, the individual companies are equipping their own fleets with custom systems that provide them with competitive advantage, but may or may not fit with eventual standards. FWWA is actively involved in defining a **National ITS Architecture** and encouraging industry participation in the standards development process to ensure National compatibility.

2.4.3 Cost Savings for Commercial Vehicle Regulators

Commercial Vehicle Regulators will also experience financial benefits due to implementation of ITS. Improvements in administrative efficiency, avoidance of infrastructure investment, and improvements in highway data collection will reduce costs while increased compliance will increase revenues and reduce damage to highways in addition to improving safety. The **HELP/Crescent Project** on the **West Coast** and **Southern border** states represented the final stage of the HELP program that evaluated four technologies applicability to services including roadside dimension and weight compliance clearance, pre-clearance of vehicles with proper documents, government audit of carrier records, government processing of commercial vehicle operator documents, government planning, and industry administration of vehicles and drivers. The technologies included automatic vehicle identification, weigh-in-motion, automatic vehicle classification, and integrated communications systems and database. The benefits data are developed as projection of experience on the project and from other databases rather than direct measurement by the project.[42] Impact of hazardous material incidents could be reduced $1.7 million annually per state. Estimates of reductions in tax evasion range from $0.5 to $1.8 million annually per state. Overweight loads could be reduced by 5% leading to a savings of $5.6 million annually. Operating costs of a weigh station could be reduced up to $160,000, with credentials checking adding $4.3-$8.6 million and automated safety inspection

40 ATA Study to be released. Update with reference and specific numbers when available

41 Regan, A., et al., Improving Efficiency of Commercial Vehicle Operations Using Real-Time Information: Potential Uses and Assignment Strategies, Presented at the 74th Transportation Research Board Annual Meeting, January 1995

42 The Crescent Project: An Evaluation of an Element of the HELP Program, The Crescent Evaluation Team, Executive Summary and Appendix A, February 1994

adding $156,000-$78 1,000 in savings due to avoided accidents annually per state. A full implementation of services examined in the Crescent project would yield a benefit cost ratio of 4.8 for state government over a 20-year period. Less complete implementations range in benefit cost ratio from negative up to 12: 1 for the government. The COVE Study[43] estimates a benefit/cost ratio to the government of 7.2 for electronic clearance, 7.9 for one-stop/no-stop shopping, and 5.4 for automated roadside inspections.

2.4.4 Cost Savings for Transit Operators

A productivity improvement reported by **Portland**[44] is the use of a bus priority system integrated with the traffic signal system on major arteries. By allowing buses to either extend green time or shorten red time by only a few seconds, the bus travel time was reduced by between 5% and 8%. This will result in faster service for the customer and would allow the use of fewer vehicles to serve that route.

The use of AVL/CAD systems has demonstrated significant productivity improvements to transit operators. In **Kansas City,** the analysis of actual run times on all routes over an extended period of time allowed a reduction in the scheduled run time in several routes, allowing fewer buses to serve those routes with no reduction in service to the customer. The result was a savings in both operating expense and capital expense by actually removing these buses from service and not replacing them. The productivity gain of eliminating seven buses out of a 200 bus system allowed **Kansas City** to amortize their investment in AVL in two years. These savings were:

Capital expense-$1,525,000
Operating expense-$404,00O/yr.
Total cost of AVL/CAD systems-$2.3M.

The **Winston-Salem Transit Authority** evaluated effects of a computer-aided dispatch and scheduling (CADS) system[45] in operation of a 17 bus fleet. While the client list grew from 1,000 to 2,000 over a 6-month period and vehicle miles per passenger trip grew 5%, operating expense dropped 2% per passenger trip and 9% per vehicle mile. These productivity improvements occurred at the same time as service improvements including institution of same day reservations, which grew to account for 10% of trips, and a decrease in passenger wait time of over 50%.

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43 Study of Commercial Vehicle Operations and Institutional Barriers, Appendix F, Booz, Allen & Hamilton, McLean, VA, November 1994

44 Kloos, W., et al., Bus Priority at Traffic Signals in Portland, ITS Annual Meeting, March 1995

45 Stone, J., Winston-Salem Mobility Management: An Example of APTS Benefits, NC State University, Interim Report, 1995

2.4.5 Reduce Travel Time

The programs as described in Section 2.2 contribute to increases in the overall capacity of the transportation system and a reduction in congestion for the general public. These programs also provide increased productivity for commercial vehicles and other business travelers, as well, in the form of travel time savings. All types of vehicles will benefit from improved incident management and equipage with route guidance capabilities.

In addition, there are specific programs that are designed to reduce travel time by the efficient management of traffic signals. A few of these are noted below.

A **Texas** state program called **Traffic Light Synchronization** has installed 166 systems in phase I and an additional 73 in phase II. Their analysis shows a benefit/cost ratio of 62: 1[46], with most of the benefits being attributed to annual savings of 43 million hours of delay.

The **Fuel Efficient Traffic Signal Management** (FETSIM) and **Automated Traffic Surveillance and Control** (ATSAC) programs in **California** showed benefit/cost ratios of 58: 1[47] and 9.8: 1[48] respectively. ATSAC, which includes computerized signal control, reported 13% reduction in travel time, 35% reduction in vehicle stops, 14% increase in average speed, 20% decrease in intersection delay, 12.5% decrease in fuel consumption, 10% decrease in HC, and 10% decrease in CO. (Reference Section 2.3.)

The **City of Abilene, Texas** installed a closed-loop signal system with hardware interconnect and modem link back to a shop computer. They are having mixed results with the new equipment in that they tried to expand coverage of the signal system at the same time that they upgraded and it is taking some time to get the system operating properly. The replacement was partly to move traffic better and partly to replace an antiquated system that was causing difficulty in locating replacements parts. The City of Abilene report[49] indicates overall impacts as shown in Table 2-3.

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46 Benefits of the Texas Traffic Light Synchronization Grant Program I; Volume I, TxDOT/TTI Report # 0258-1, Texas Department of Transportation, Austin, Texas, October 1992

47 Institute of Transportation Studies, University of California, Fuel-efficient Traffic Signal Management: Three Years of Experience, 1983 - 1985, Berkeley, CA: ITS Publications: 1986

48 Amiri, S., LACMTA, Telephone Interview Quoting Earlier Studies

49 Evaluation Study, Buffalo Gap Road, Abilene Signal System, Prepared for the City of Abilene, Texas, Orcutt Associates, 1994

Table 2-3

Performance Measure	Impact
Travel Time	-13.8%
Delay	-37.1%
Travel Speed	+22.2%
Number of Stops	+.3%
Fuel Consumption *	-5.5%
CO Emission *	-12.6%
HC Emission *	-9.8%
NOx Emission *	+4.2%

* (Reference Section 2.3.)

Overall Impacts of Closed-loop **Signal System,** *City of Abilene, Texas*

2.5 ENHANCE THE PERSONAL MOBILITY AND THE CONVENIENCE AND COMFORT OF THE SURFACE TRANSPORTATION SYSTEM

There are three primary objectives of this ITS goal: enhance traveler security, reduce travel stress, and improve accessibility to transportation.

The following programs address benefits from enhancing traveler security and improving access to transportation.

For **the Transit** riding public, safety is a crucial issue. Everyday there are numerous emergency situations in every major city involving passenger and operator safety. The deployment of Automatic Vehicle Location systems coupled with modern **Computer Aided Dispatch** has had a dramatic affect on the response to emergencies. The AVL/CAD systems now being deployed have two key features which contribute to passenger safety. First, these systems have a silent alarm capability where the driver can alert the dispatch center of a problem. When this alarm is activated, the vehicle in trouble is highlighted on the dispatcher's console for immediate response. The dispatcher can activate a covert microphone on the bus and listen to the nature of the problem without alerting the perpetrators or passengers. The dispatcher can then alert the appropriate emergency service.

A number of **Transit** agencies have reported a dramatic reduction in response time. The fact that the dispatcher can pinpoint the vehicle at all times, and is able to advise the police of the nature of the problem has produced a reduction in response time from over ten minutes to less than two minutes[50]. At least one dispatcher in **Denver** believes that this capability has literally saved the lives of some passengers.

50 Jones, W., ITS America Research Survey, 1995

The Los Angeles Smart Traveler project has deployed a small number of information kiosks in locations such as office lobbies and shopping plazas[51]. The number of daily access range from 20 to 100 in a 20-hour day, with the lowest volume in offices and the greatest in busy pedestrian areas. The most frequent request was for a freeway map with 83% of users requesting this information. Over half of the accesses included requests for MTA bus and tram information. Users, primarily upper middle class in the test area, were overwhelmin gly positive in response to a survey.

51 Giuliano, G., et al., Los Angeles Smart Traveler Information Kiosks: A Preliminary Report, Presented at the 74th Transportation Research Board Annual Meeting, January 1995

OBSERVATIONS

SECTION 3

This study represents a first attempt to catalogue some of the emerging benefits of ITS that result from some level of deployment. A few observations not related to specific ITS goals are provided and some next steps are identified.

3.1 PUBLIC ACCEPTANCE OF TRAVEL MANAGEMENT

While many positive results of **ITS technology** deployment have been experienced and more are anticipated, new systems also bring negative effects. People have mixed reviews about the use of technology to limit their freedom, even when the management of the transportation system can show overall benefit. **J. B. Hunt** and **Schneider** both use devices to track the location of their trucks and the driving habits of their employees. **Ramp meters** and **high occupancy vehicle** (HOV) lanes have compliance problems even when their implementation can be shown to reduce overall travel time. Disregard of traffic signals remains a problem, with 12 fatalities in the state of Maryland attributed to failure to obey a red signal in 1993 as an example[52].

3.2 BENEFITS ASSESSMENT

Because of the sketchy nature of the benefits data currently available from the field, it is risky at this time to draw any firm conclusions about the degree of attainment of any goal. However, we are just beginning to enter a period of time where operational tests results for a number of ongoing programs will become readily available.

The benefits assessment of ITS products should be viewed as a continuing process requiring periodic collection, analysis and dissemination. Over time additional data will become available, both for expected benefits, and for other unanticipated benefits. The challenge for the ITS program is to define a methodology to describe benefits and to relate them to the overall program goals.

A first step in this process has begun as part of a meta-evaluation study of ITS benefits. While the current report organizes benefits data under primary objectives of the ITS goals, the meta-evaluation goes a step further to define specific measures-of-effectiveness (MOEs) for each of these primary objectives. For example, for the Goal of Improve Safety with an Objective to Reduce the Frequency of Accidents, a direct MOE is Accident rate, with a surrogate MOE of Enhanced Driver Performance and associated MOEs of Frequency of

52 Washington Post, 9 February 1995

Abrupt Maneuvers and Response Time. An example of an ITS device that does enhance driver performance would be **Forewarn.** We recommend that as further benefits data are gathered that they are described in terms of these MOEs whenever possible.

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52. Washington Post, Washington, DC, 9 February 1995

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ITS ACRONYMS

AHS	Automated Highway System
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
ATSAC	Automatic Traffic Surveillance and Control
AVL	Automatic Vehicle Location
AVMC	Advanced Vehicle Monitoring and Communications
CAD	Computer-aided Dispatching
CADS	Computer-aided Dispatch and Scheduling
c o	Carbon Monoxide
c v o	Commercial Vehicle Operations
DOT	Department of Transportation
ETC	Electronic Toll Collection
FETSIM	Fuel Efficient Traffic Signal Management
FHWA	Federal Highway Administration
GPS	Global Positioning System
HC	Hydrocarbon
HOV	High Occupancy Vehicle
INFORM	Information for Motorists
ITS	Intelligent Transportation Systems
LORAN	Long RAnge Navigation
MOEs	Measures of Effectiveness
MVM	Million Vehicle Miles
NESCAUM	Northeast States for Coordinated Air Use Management
NOx	Oxides of Nitrogen
TDM	Traffic Demand Management
TMC	Traffic Management Center
VMSs	Variable Message Signs
VMT	Vehicle Miles Traveled
VPLPH	Vehicles Per Lane Per Hour

GLOSSARY